LINKING WATER, HUMAN DEVELOPMENT AND ECONOMIC GROWTH: BUILDING EMPIRICAL EVIDENCE USING GLOBAL DATASETS

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Abstract – *In this paper, the authors analyze the nature of linkage between water situation of a country, vis-à-vis its access and use, water environment and institutional capabilities in the water sector, and its economic growth. In order o realistically assess the water situation of a country, a new index 'Sustainable Water Use Index' (SWUI) was derived from Water Poverty Index (WPI). For the analysis, data on SWUI derived from WPI, human development index (HDI) and per capita GDP for 145 countries, and global hunger index (GHI) for 117 countries are used. Analysis showed that improved water situation in a country can drive economic growth through the human development route as indicated by the strong correlation between SWUI and per capita GDP, and SWUI & HDI. The strong linkage between SWUI and HDI is explained by the reduction in malnutrition and infant mortality with improvement in water situation.*

1.0 INTRODUCTION

As water scarcity hits many developing regions of the world, internationally, there is a renewed interest in understanding how growing threats to water security affects future progress in human development and economic growth of nations (see Sadoff and Grey, 2005). The international development debate is, however, heavily polarized between those who believe that policy reforms in the water sector would be crucial for bringing about progress in human development and those who believe that economic growth itself would help solve many of the water problems, which countries in their economic transition and many backward regions, are facing today (HDR, 2006: pp66). Such debates, that are often not healthy, are causing delays in deciding investment priorities in water sector, particularly in the developing world (Biswas and Tortajada, 2001). The underlying concern here is that water insecurity could decouple economic growth and progress in human development.

There is rich theoretical discussion on the returns on investment by countries in water infrastructure and institutions (Sadoff and Grey, 2005). Many scholars and international agencies have provided robust evidence to the effect that water security can catalyze human development and growth (World Bank, 2004; 2006a & b; Briscoe, 2005). But, the number of regions for which these evidence are available is too limited for evolving a global consensus on this complex issue**.** Till recently, there were no authentic and comprehensive database on various factors influencing water security for sufficient number of countries which are at different stages of human development and economic growth. This contributed to the complexity of the debate. The water poverty index (WPI), conceived and developed for countries by C. Sullivan (2002), and the international comparisons now available from a recent work by Laurence, Meigh and Sullivan (2003) for 145 countries enable us to provide an empirical basis for enriching the debate.

But, the WPI is a composite index consisting of five sub-indices, viz., water access index, water use index, water endowment index, water environment index and institutional capacities in water sector. In order to realistically assess the water situation of a country, which can capture the crucial attributes like access to water for various uses; level of use of water in different sectors; condition of the water environment; and technological and institutional capacities in water sector, a new index called Sustainable Water Use Index (SWUI) is derived from WPI. The paper provides empirical analysis using global database on SWUI and many other water and development indicators to enrich the debate "how water security is linked to human development and economic growth".

2.0 THE GLOBAL DEBATE ON WATER, DEVELOPMENT AND GROWTH

The debate on the linkage between water, growth and development is characterized by divergent views. While the general view of international scholars, who support large water resource projects, is that increased investment in water projects such as irrigation, hydropower and water supply and sanitation acts as engines of growth in the economy, while supporting progress in human development (for instance see Briscoe, 2005; HDR, 2006). They harp on the need for investment in water infrastructure and institutions. Sadoff and Grey (2005) suggests that there is a minimum platform of water security, achieved through the right combination of investment in water infrastructure and institutions and governance, which is essential if poor countries are to use water resources effectively and achieve rapid economic growth to benefit vast numbers of their population. They suggest an S-curve for growth impacts of investment in water infrastructure and institutions in which returns continue to be nil for early investments. They argue that for poor countries, which experience highly variable climates, the level of investment required to reach the tipping point of water security[1] would be much higher as compared to countries, which fall in temperate climate with low variability. But, they suggest that for developing countries, the returns on investment in infrastructure would be higher that in management and vice versa for developed countries.

Many environmental groups, on the other hand, advocate small water projects which, according to them, the communities can themselves manage. The solutions advocated are: watershed management; small water harvesting interventions; and community-based water supply systems; and, micro-hydro electric projects (Dharmadhikary, 2005; D'Souza, 2006).

The proponents of sustainable development paradigms believe that the ability of a country to sustain its economic growth depends on the extent to which natural resources, including water, are put to efficient use through technologies and institutions, thereby reducing the stresses on environmental resources (Drexhage and Murphy, 2010). Here, the focus is on initiating institutional and policy reforms in water sector. An alternative view suggests that countries would be able to tackle their water scarcity and other problems relating to water environment at advanced stages of economic development (Shah and Koppen, 2006). They argue that standard approaches to water management in terms of policies and institutions work when water economies become formal, which are found at an advanced stage of economic development of nations.

3.0 OBJECTIVES AND HYPOTHESIS

The objectives of the paper are to: i] analyze the nature of linkage between water situation of a country, comprising improved water access and use, water environment and institutional capacities in the water sector, and economic growth of a nation; and ii] understand the role of large water storages in boosting economic growth and changing human development indicators of countries which fall in hot and arid, tropical climates.

We have three propositions. First: improving the water situation through investments in water infrastructure, institutions and policies would help ensure economic growth through the human development route. Second: nations can achieve reasonable progress in human development even at low levels of economic growth, through investment in water infrastructure, and welfare policies The hypotheses is: 1] improved water situation supports economic growth through the human development route.

4.0 ANALYSIS AND DATA SOURCES

The values of Sustainable Water Use Index were calculated by adding up the values of four of the sub-indices of Water Poverty Index, viz., water access index, water use index, water environment index and water capacity index.

The first hypothesis is tested using a regression of global data on: Sustainable Water Use Index (SWUI), and data on per capita GDP (ppp adjusted); SWUI and GHI; and SWUI and HDI. Since regression between SWUI and HDI showed a strong relationship (R^2= 0.80), the causality, i.e., whether SWUI influences GDP growth or vice versa, can be tested by running regression between per capita GDP and a decomposed HDI, which contain the indices for health and education. The underlying premise is that if economic growth drives water situation, then it should change the indicators of human development that are independent of income levels, such as health and education, and that which are inter-related with water situation.

Data on per capita GDP and HDI were obtained from Human Development Report 2009. Data on GHI[2] for 117 countries were obtained from Wiesmann Doris (2007).

1. Beyond which the investment in water infrastructure and institutions yields positive growth impacts.
2. This is an indicator of the proportion of the population living in under-nourished conditions and the child mortality rate (see Wiesmann Doris, 2006).

Data on WPI for 145 countries were obtained from Laurence et al. (2003).

5.0 WATER AND ECONOMIC GROWTH

Before we begin to answer this complex question of "what drives what", we need to understand what realistically represents the water richness or water poverty of a country. A recent work by Kellee Institute of Hydrology and Ecology which came out with international comparisons on water poverty of nations had used five indices, viz., water resources endowment; water access; water use; capacity building in water sector; and water environment, to develop a composite index of water poverty (see Laurence, Meigh and Sullivan, 2003).

Among these five indices, we chose four indices as important determinants of water situation of a country, and the only sub-index we excluded is the water resources endowment. We consider that this sub-index is more or less redundant, as three other sub-indices viz., water access, water use and water environment take care of what the resource endowment is expected to provide. Our contention is that natural water resource endowment becomes an important determinant of water situation of a country only when governance is poor and institutions are ineffective, adversely affecting the community's access to and use of water, and water environment. Examples are the droughts in Sub-Saharan African countries. This argument is validated by a recent analysis which showed strong correlation between rainfall failure and economic growth performance in these countries. That said, all the four sub-indices we chose significant implications for socio-economic conditions, and are influenced by institutional and policy environment, and therefore have human element in them. Hence, such a parameter will be appropriate to analyze the effect of institutional interventions in water sector on economy.

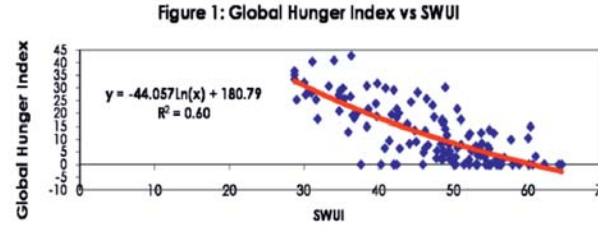
It is being hypothesized that that the overall water situation of a country (or SWUI) has a strong influence on its economic growth performance. This is somewhat different from the hypothesis postulated by Shah and Koppen (2006), wherein they have argued that economic growth (GDP per capita), and HDI are determinants of water access poverty and water environment.

It is important to provide empirical evidence to this. Worldwide, experiences show that improved water situation (in terms of its access to water; levels of use of water; the overall health of water environment; and enhancing the technological and institutional capacities to deal with sectoral challenges) leads to better human health and environmental sanitation; food security and nutrition; livelihoods; and greater access to education for the poor (see for instance UNDP, 2006). This aggregate impact can be segregated with irrigation having direct impact on rural poverty (Lipton, 2007; Hussain and Hanjra, 2003); irrigation having impact on food security, livelihoods and nutrition (Hussain and Hanjra, 2003), with positive effects on productive workforce; and domestic water security having positive effects on health, environmental sanitation, with spin off effects on livelihoods and nutrition (positive), school dropout rates (negative) and productive workforce.

According to the Human Development Report (2006), only one in every five people in the developing world has access to an improved water source. Dirty water and poor sanitation account for vast majority of the 1.8 million child deaths each year (almost 5,000 every day) from diarrhea- making it the second largest cause of child mortality. In many of the poorest countries, only 25% of the poorest households have access to piped water in their homes, compared with 85% of the richest. Diseases and productivity losses linked to water and sanitation in developing countries amount to 2% of GDP, rising to 5% in Sub-Saharan Africa—more than the aid the region gets. Women bear the brunt of responsibility for collecting water, often spending up to 4 hours a day walking, waiting in queues and carrying water; water insecurity linked to climate change threatens to increase malnutrition to 75–125 million people by 2080, with staple food production in many Sub-Saharan African countries falling by more than 25%.

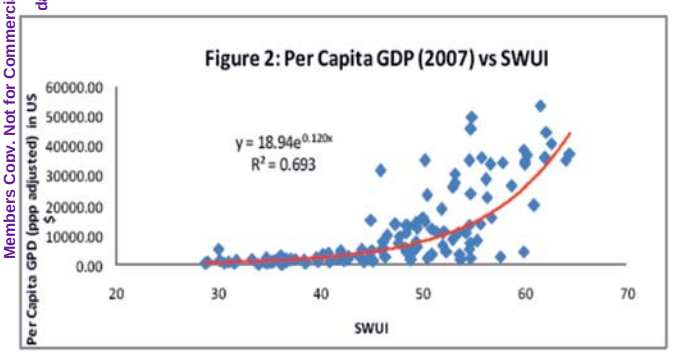
The strong inverse relationship between SWUI and the global hunger index (GHI), developed by IFPRI for 117 countries, provide a broader empirical support for some of the phenomena discussed above. In addition to these 117 countries for which data on GHI are available, we have included 18 developed countries. For these countries, we have considered zero values, assuming that these countries do not face problems of hunger. The estimated R square value for the regression between SWUI and GHI is 0.60. The coefficient is also significant at one per cent level. It shows that with improved water situation, the incidence of infant mortality (below five years of age) and impoverishment reduces (Figure 1). In that case, improved water situation should improve the value of human development index, which captures three key spheres of human development such as health, education and income status.

Figure 1: Global Hunger Index vs SWUI



That said all the sub-indices of HDI have strong potential to trigger growth in economy of a country, be it educational status; life expectancy; or income levels. When all these factors improve, they could have a synergetic effect on the economic growth. Hence, the "causality" of water as a prime driver for economic growth can be tested if we are able to establish correlation between water situation and HDI. This we would examine at a later stage in this paper.

Before that, we would first look at how water situation and economic growth of nations are correlated. Regression between sustainable water use index (SWUI) and ppp adjusted per capita GDP for the set of 145 countries shows that it explains level of economic development to an extent of 69 per cent (see Figure 2). The coefficient is significant at one per cent level. We must mention here that Laurence, Meigh and Sullivan (2003) had estimated an R^2 value of 0.81 for WPI and HDI (source: Table 2: page 5, Laurence et al., 2003). Figure 2 shows that the relation between SWUI and per capita GDP is a power function. Any improvement in water situation beyond a level of 50 in SWUI, leads to exponential growth in per capita GDP.



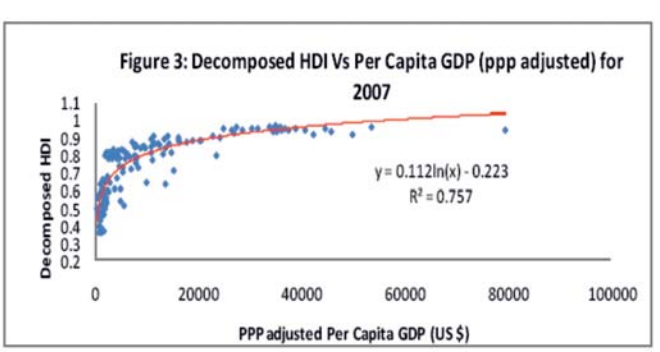
This only means that for countries to be on the track of sustainable growth path, the following steps are needed: 1] investment in infrastructure, and institutional mechanisms and policies to: a] improve access to water for all sectors of use and across the board, b] enhance the overall level of use of water in different sectors, and c] regulate the use of water, reduce pollution and provide water for ecological services; and 2] investment in building human resources and technological capabilities in water sector to tackle new challenges in the sector. Regression with different indices of water poverty against economic growth levels shows that the relationship is less strong, meaning all aspects (water access, water use, water environment and water sector capacity) are equally important to ensure growth.

Major variations in economic conditions of countries having same levels of SWUI (in the range of 53-56), can be explained by the economic policies of which the country pursues. Some countries of central Asia viz., Uzbekistan, Kyrgyzstan and Turkmenistan and Latin American countries viz., Ecuador, Uruguay, Colombia and Chile have values of SWUI as high as North America and northern European countries, but are at much lower levels of per capita GDP. While North America and north, west and southern European countries have capitalist and liberal economic policies, these countries of old soviet block and Latin America have socialist and welfare oriented policies.

5.1 Can Water Security Ensure Economic Growth?

If the stage of economic development determines a country's water situation rather than the reverse, the variation of human development index, should be explained by variation in per capita GDP, rather than water situation in orders of magnitude. We have used data for 145 countries to examine this closely. The regression shows that per capita GDP explains HDI variations to an extent of 90 per cent (R2=0.90). The regression equation was Y =0.129ln (X)-0.398. But, it is important to remember that HDI already includes per capita income, as one of the sub-indices.

Therefore, analysis was carried out using decomposed values of HDI index, after subtracting the per capita income index, the graphical representation of which is presented in Figure 3. The regression value came down to 0.75 (R^2=0.75) when the decomposed index, which comprises education index and life expectancy index, was run against per capita GDP. What is more striking is the fact that 21 countries having per capita income below 2,000 dollars per annum have medium levels of decomposed index. Again 50 countries having per capita GDP (ppp adjusted) less than 5,000 dollars per annum have medium levels of decomposed HDI. Significant improvements in HDI values (0.30 to 0.9) occur within the small range in per capita GDP. The remarkable improvement in HDI values with minor improvements in economic conditions, and then "plateauing" means that improvement in HDI is determined more by factors other than economic growth. Our contention is that the remarkable variation in HDI of countries belonging to the low income group can be explained by the quality of governance in these countries, i.e., whether good or poor.



Many countries that show high HDI also have good governance systems and practices, and institutional structures to ensure good literacy and public health. For instance, Hungary in eastern Europe; some countries of Latin America viz., Uruguay, Guatemala, Paraguay, Nicaragua and Bolivia; and countries of erstwhile Soviet Union viz., Turkmenistan, Kyrgykistan and Armenia have welfare-oriented policies. They make substantial investment in water, health and educational infrastructure[3].

Incidentally, many countries, which have extremely low HDI, have highly volatile political systems and ineffective governance, and corruption. The investments in building and maintenance of water infrastructure are consequently very poor in these countries (Shah and Kumar, 2008) in spite of huge external aid. Sub-Saharan African countries, viz., Angola, Benin, Chad, Eritrea, Ethiopia, Burundi, Niger, Togo, Zambia and Zimbabwe; and Yemen from Middle East belong to this category. Sub-Saharan Africa has the lowest irrigated to rain-fed area ratio of less than 3% (FAO, 2006, Figure 5.2: pp 177), where as Ethiopia has the lowest water storage of 20m^3/capita in dams (World Bank, 2005). How water security decoupled human development and economic growth in many regions of the world were illustrated in the recent human development report (HDR, 2006: pp 30-31).

The overall public expenditure on health and education is extremely low in these African countries and Yemen when compared to the many other countries which fall under the same economic category (below US $ 5,000 per capita per annum). Over and above, the pattern of public spending is more skewed towards military (see Table 1 based on data provided in HDR, 2006, Table 19: pp 348-351). Besides, access to water supply and sanitation is much higher in the countries which have higher HDI, as compared to those countries which have very low HDI (based on data in HDR, 2006, Table 7, pp306-309).

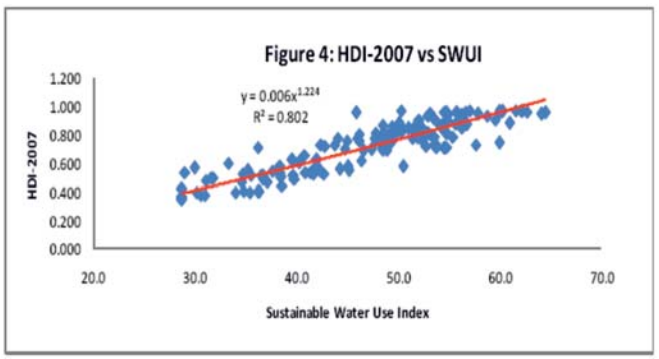
Table 1: Pattern of Public Expenditure on Military, Health & Education and Status vis-à-vis Water & Sanitation

Name of Country	Per Capita Expenditure (US $) on		Percentage of Population Having Access to	
	Military	Health and Education	Water Supply	Sanitation
Armenia	106.626	180.444	92	83
Bolivia	54.4	291.04	85	46
Guatemala	17.252	146.642	95	86
Kyrgyzstan	38.7	127.71	77	59
Nicaragua	25.438	247.112	79	47
Paraguay	33.69	317.66	86	80
Peru	68.136	289.578	83	63
Tajikistan	26.444	44.474	59	51
Togo	24.57	58.37	52	35
Yemen	59.202	19.734	67	43
Zambia	34.891	52.808	58	55
Burundi	42.651	39.943	79	36
Ethiopia	64.26	51.408	22	13

Source : Based on Data Provided in HDR, 2006: Table 19: pp 348-151 & Table 7, pp 306-309

High incidence of water-related diseases such as malaria and diarrhea, high infant mortality, high school dropout rate mainly due to lack of access to safe drinking water; and physical and economic scarcity of irrigation water in rural areas, poor agricultural growth, high food insecurity, malnutrition etc. are characteristic of these regions (HDR, 2006). Consequently, their HDI is very low, as also shown by the international literature which illustrates how water insecurity decouples human development from economic growth.

Contrary to the above discussed scenario, regression between sustainable water use index and HDI values for 2007 shows that it explains variation in HDI in a much better way than the level of economic development (Figure 4). This is in spite of the fact that human development index as such does not include any variable that explicitly represents access to and use of water for various uses; overall health of water eco-system; and capacities in the water sector as one of its sub-indices. The R square value was 0.80 against 0.75 in the earlier case when per capita GDP is run against decomposed HDI. Also, the coefficient was significant at one per cent level. More importantly, the relationship was linear (Figure 4), unlike the logarithmic relationship found in the earlier case. It means that variation in human development index



can better be explained by *water situation* in a country, expressed in terms of sustainable water use index, than the ppp adjusted per capita GDP (Kumar, 2009). Now, such a strong linear relationship between sustainable water use index and HDI explains the exponential relationship between sustainable water use index and per capita GDP as the improvements in sub-indices of HDI contributes to economic growth in its own way (i.e., per capita $GDP = f\{EI, HI\}$; here EI is the education index, and HI is the health index).

While an alternative to analyze the impact of a country's water situation on its economic growth performance is to look at the historical data on: cumulative investments in water sector, water access and use by population in different sectors, change in water environment, and economic conditions for individual nations, such data are seldom available on a time series basis. Under such a circumstance, the best way to go ahead is to analyze the impact of natural water endowment, i.e., rainfall on economic growth in a situation where investments in infrastructure and institutions and governance mechanisms for improving water access and use and water environment are poor. The reason is that under such situations, the water access, water use, and water environment would be highly dependent on natural water endowment.

There cannot be a better region than Sub-Saharan Africa to illustrate such effects. A recent analysis showed a strong correlation between rainfall trend since 1960s and GDP growth rates in the region during the same period, which argued that the low economic growth performance could be attributed to long term decline in rainfall which the region experienced (Barrios *et al*., 2004). Such a dramatic outcome of rainfall failure can be explained partly by the failure of the governments to build sufficient water infrastructure. Sub-Saharan Africa has smallest proportion of its cultivated area (< 3%) under irrigation (HDR, 2006). Due to this reason, reduction in rainfall leads to decline in agricultural production, food insecurity, malnutrition, loss of employment opportunities and an overall drop in economic growth in rural areas.

The foregoing analyses suggest that improving *water situation* of a country, which is represented by sustainable water use index, is of paramount importance if we need to sustain economic growth in that country. It would be rather an improper logic to consider that a country can wait till its economy improves to a certain level to start tackling its water problems. While the natural water endowment in both qualitative and quantitative terms cannot be improved through ordinary measures, the *water situation* can be improved through economically efficient, just and ecologically sound development and use of water in river basins.

6.0 SUMMARY OF FINDINGS

In this paper, we analyzed the nature of impact the water situation of a country has on its economic growth by running regression between: SWUI and GHI; SWUI and per capita GDP; SWUI and HDI; and per capita GDP and HDI for 145 countries. Our analysis shows that improving the water situation vis-à-vis improved access to and use of water, institutional capabilities in water sector and improved water environment, through investments in water infrastructure, creation of institutions and introduction of policy reforms, can trigger economic condition in a nation. This occurs through the human development route, as shown by the consistent improvement in human development indicators with increase in values of SWUI. This strong linkage can be partly explained by the reduction in malnutrition and infant mortality, with improvement in water situation as indicated by the strong inverse relationship between SWUI and GHI for 117 countries.

Further, progress in human development has very little to do with their economic growth, and that they could achieve good indicators of development even at low levels of economic growth, through investment in water infrastructure and welfare-oriented policies. Many countries of the erstwhile Soviet Union, and communist countries of Latin America, which have low income, spend a significant portion of public funds in health and education, against many poor countries of Sub-Saharan Africa, which spend much less for health and education and more for military.

7.0 CONCLUSIONS AND POLICY

Scholars have provided robust evidence to the effect that water security catalyses human development and economic growth. But, number of regions for which the evidence is available is too limited to evolve a global consensus on this complex issue. Water poverty index, conceived and developed by C. Sullivan (2002), and the international comparisons now available from Laurence, Meigh and Sullivan (2003) for 147 countries enable us to provide an empirical basis for the argument. A new index called SWUI was derived from WPI using four of its five

sub-indices to assess the water situation of a country, vis-à-vis access and use of water, water environment and institutional capabilities in the water sector. Analysis was carried out using global datasets on SWUI, GHI, HDI and per capita GDP to understand the nature of linkage between water situation of a country and its economic growth.

Findings show that economically poor countries, which also show very poor indicators of human development, need not wait till the economic conditions improve to address water sector problems. Instead, they should start investing in building water infrastructure, create institutions and introduce policy reforms in water sector that could lead to improved water situation vis-à-vis access to and use of water, water environment and institutional capabilities. Only, this can support progress in human development, and sustain economic growth, through poverty reduction; food security, improved livelihoods and nutrition, with positive effects on productive workforce; and domestic water security with positive effects on health, environmental sanitation, with spin off effects on livelihoods and nutrition, school dropout rates and productive workforce.

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